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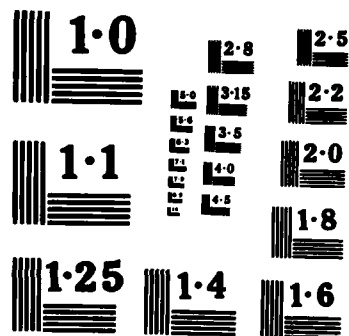
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COMPUTER-CONTROLLED OPHTHALMIC REFRACTION

Quarterly Report

Elwin Marg, O.D., Ph.D.

July 1975  
(For April-June 1975)

Supported by

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Fort Detrick, Frederick, Maryland 21701

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University of California  
Berkeley, California 94720

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1. TITLE: Computer-Controlled Ophthalmic Refraction

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3. ABSTRACT:

↳ Our mission is to perform the necessary research and development to provide a system for computer-assisted ophthalmic refraction, including the basic concepts and flow charts, software, optical and electronic hardware, and testing and clinical evaluation. The project is to culminate with a system installed and operating in Letterman General Hospital of the San Francisco Presidio, in the second quarter of 1975, where it is to be evaluated on Army personnel, during the third quarter.

4. STATEMENT OF THE PROBLEM

A. HISTORY

The basic problem is to bring the power of modern technology in the form of interactive automation to bear on the problems of eye examination. The principal thrust is to produce a system which will perform subjective eye examinations of the refractive state. To the best of our knowledge, no one else has attacked or is attacking the problem in this way, which is the only valid one for obtaining maximum visual acuity. No other method can obtain automatically the maximum visual acuity of a patient. For example, three automated retinoscopes have been devised which obtain a refractive reading but this is not adequate for prescription because the maximum visual acuity is not obtainable. These instruments are: the Acuity Systems, Inc. 6600 Auto-Refractor; Safir's Ophthalmatron of Bausch & Lomb, Inc.; and Coherent Radiation's Dioptron. Two subjective instruments which do give maximum visual acuity are soon to become available. One is the Guyton

Astigmatic Optometer. This will not be available for two years and if successful, will still need automation. The other is the Humphrey Refractor which is a substitute for a conventional refractor. It can combine many of the instruments used in eye examinations such as retinoscopy, ophthalmoscopy, etc. It is to be commercially available in the summer of 1975. However, if it is successful, it will still be a manual method that will have to be automated to perform a similar function to ours. Our system is the only one which is providing an automated subjective refraction which automatically gives a refractive prescription yielding maximum visual acuity without accommodation.

#### B. INTEREST

Interactive computer-assisted eye examination was originated in concept by us about 10 years ago. We have been working on it continuously ever since, at various rates according to the resources available. It is a multi-disciplinary problem which includes originating new software, new specialized I/O terminals, and the necessary conceptualized flow charts to govern the system.

#### C. IMPORTANCE -- SCOPE

Computer assistance in eye examinations is important because:

1. It can provide service in an emergency situation where adequate numbers of skilled eye examiners are not available. For example, it might be used in forward areas, in training centers where a sudden influx of recruits must be accommodated, or to reduce the workload in a general hospital where there are not enough doctors to take care of the patient load.
2. It should improve availability and reduce access time, that is, the waiting period for an eye examination, since the equipment can be run around the clock.

3. It is expected that it will reduce the costs of the examination, since computation costs are continuously falling whereas personnel costs are continuously rising.

#### D. FORMAL STATEMENT

The question for which we expect to provide an affirmative answer is: "Can we improve availability and access, as well as ultimately reduce costs, for eye examinations?"

### 5. THEORETICAL FRAMEWORK

#### A. ASSUMPTIONS AND SUBPROBLEMS AND LIMITS

Only two assumptions are made: 1) that the patient is cooperative and not a malingerer; and 2) that he has adequate intelligence to follow instructions on which button to push.

#### B. HYPOTHESIS

Although every effort is made to make the instructions as simple as possible, there undoubtedly will be some lower level of intelligence that will not be able to follow the instructions. However, we assume that our projected patient population will not be this low. It is believed that the great majority of patients will have no serious difficulty following the instructions, on the basis of our experience to date.

#### C. RELATIONSHIP TO PREVIOUS RESEARCH, LITERATURE REVIEW

All previous research in this field is found in our list of publications, which follows:

Computer-assisted eye examination: IV "additive" lens systems in eye refractors (M.M. Lang and E. Marg) American Journal of Optometry and Physiological Optics, in press, 1975.

Computer-assisted eye examination: III Physiological indices for subjective refraction. (G. Hung and E. Marg) American Journal of Optometry and Archives of the American Academy of Optometry, 50/12, 968-977, December 1973.

Computer-assisted eye examination: II Visual evoked response meridional refractometry. (G. McCormack and E. Marg) American Journal of Optometry and Archives of American Academy of Optometry, 50/11, 889-903, November 1973.

Computer-assisted eye examination: I Computer-actuated refractors. (E. Marg) American Journal of Optometry and Archives of American Academy of Optometry, 50/8, 601-615, August 1973.

A software implementation of a computer-controlled ophthalmic refraction system. (S. Greenfield, Chacko Neroth, and E. Marg) Technical report, December 28, 1972, for Contract No. DADA17-72-C-2044. AD#757775, National Technical Information Service (NTIS), Springfield, VA 22161.

A hardware interface for a computer-controlled ophthalmic refraction system. (P. Chang, C. Neroth, and E. Marg) Technical report, August 15, 1972 for Contract No. DADA17-72-C-2044. AD#751676, NTIS, Springfield, VA 22161.

Optometrists' human and computer assistants. (E. Marg and Rebecca Ng) Journal of Occupational Medicine, 14/5, 375-362, May, 1972. Reprinted in Optometric Weekly, 63/34, 829-837, August 24, 1972.

An automatic, branching case-history taker for eye examinations: design and clinical evaluation. (E. Marg, E.R.F.W. Crossman, P.J. Goodeve and H. Wakematsu) American Journal of Optometry and Archives of American Academy of Optometry, 49/2, 105-112, February 1972.

An information-theoretic analysis of clinical refraction. (E.R.F.W. Crossman, P.J. Nagarvala and E. Marg) American Journal of Optometry and Archives of American Academy of Optometry, 48/5, 391-406, May 1971.

A computer-based automatic method for determining visual acuity. (E.R.F.W. Crossman, P.J. Goodeve and E. Marg) American Journal of Optometry and Archives of American Academy of Optometry, 47/5, 344-355, May 1970.

Towards computer-assisted optometry. Simulated automatic visual acuity measurement for computer ophthalmic refraction. (E. Marg, G. Liberman and E.R.F.W. Crossman) Optometric Weekly, 60/45, 17-20, November 6, 1960.

#### D. POSSIBLE MISTAKES AND THEIR CONSEQUENCES

If the level of intelligence of our patient population is not adequate to perform in accordance with the instructions in the interactive program, then it may be that we may get a yield in terms of a successful prescription of something less than the expected 95-99%.

#### 6. DEFINITION OF TERMS (OPERATIONALIZATION) FOR EACH PROBLEM OR SUBPROBLEM

Our system is comprised of a large number of diverse designs and of interacting variables which cannot be categorized in this way.

#### 7. METHODOLOGICAL APPROACH FOR EACH PROBLEM OR SUBPROBLEM

This breakdown is not applicable for our approach, which is a complex, interactive, psychological, physiological, software, hardware design.



## 8. DATA ANALYSIS PLAN

### A. STATISTICAL MODEL

Comparison of automated and manually obtained prescription by the measurement of scatter of the sphere, cylinder and axis of each eye.

### B. DUMMY TABLES

Not applicable.

### C. PRETESTING

The pretesting of programs is being accomplished on Refractor II. The basic programs for Refractor III are already largely developed.

### D. RELIABILITY AND VALIDITY FACTORS

This is scheduled for the final testing of Refractor III at the Letterman General Hospital in San Francisco. However, since the construction of the facility has been delayed it will be necessary to test during the fourth quarter, October-December, by extension of support. Comparisons will be made between the results of the new system in direct comparison with the manual results accomplished in an Army hospital environment.

## 9. THE BUDGET

Not applicable to this report.

## 10. INTERPRETATION OF RESULTS

The results will be interpreted by a comparison of patient visual acuity from prescriptions indicated by the system in direct comparison with the patient acuity determined by the prescription given by an optometrist or ophthalmologist. For this comparison, the effectivity error inherent in a conventional manual refraction also will be taken into account. In addition to that, comparisons will be made of patient satisfaction and comparative cost.

As for the subjects, we plan to have at least 50 percent of them active duty personnel, both male and female, and we expect that we will learn something about how young a person can successfully use our system. Of course, we will have each subject sign the officially-approved consent form and we will be especially careful to inform the subjects that they are under no obligation to continue the test if they do not wish to nor need they wait for the test if they do not feel so inclined. The report of the results will be written in the format of a paper for a scientific or professional journal.

#### 11. PUBLICATION OR REPORTING PLAN

##### A. WHAT FORM

We already have embarked on a publication plan. In the Bibliography (see list under 5C, Literature Review, above) are the papers we have published in the literature to date, as well as two technical reports. Other publications and technical reports are planned. It is expected that as the project is completed, a book containing details of the research, development and results will be written and published.

We currently have in press a paper by Lang and Marg entitled: Computer-assisted eye examination: IV "additive" lens systems in eye refractors. It is expected that this paper will be published in August.

##### B. EXPECTED CONSEQUENCES OF REPORTING PLAN

The dissemination of our concepts and the research and development to implement them is expected to reach a critical audience of experts in the field of computerized health care delivery of eye care so that the concepts might be applied on a larger scale for general hospitals and ultimately for civilian use.

#### 12. BIBLIOGRAPHY

See listing in 5.C.

**DISTRIBUTION LIST**

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